

## PSET 1: Theory of Gravitation

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### 0 Conceptual Questions

- (i) Explain *why* the gravitational potential energy between two masses is negative. Note: saying “because that’s what the equation gives” is *not* a valid answer.
- (ii) The escape speed from Planet X is 10,000 m/s. Planet Y has the same radius as Planet X, but is twice as dense. What is the escape speed from Planet Y?
- (iii) Explain what is a geosynchronous orbit is, and explain what are the necessary conditions for such an orbit.

### 1 Newton’s Law of Gravitation

A 20 kg sphere is at the origin and a 10 kg sphere is at  $x = 20$  cm. At what position on the  $x$ -axis could you place a small mass such that the net gravitational force on it due to the spheres is zero?

### 2 Geosynchronous orbits on Mars

What are the speed and height of a geosynchronous satellite orbiting Mars? Mars rotates about its axis every 24.8 hours.

### 3 Orbital Energetics

Show that, for a satellite in a circular orbit,  $K = -\frac{1}{2}U_G$ .

### 4 Raising a satellite

How much work must be done to boost a 1000 kg communications satellite from a low earth orbit with  $h = 300$  km to a geosynchronous orbit?

## 5 Schwarzschild radius

Nothing can escape the *event horizon* of a black hole, not even light. You can think of the event horizon as being the distance from a black hole at which the escape speed is the speed of light  $c = 3 \times 10^8$  m/s, making all escapes impossible. What is the radius of the event horizon for a black hole with a mass 5.0 times the mass of the sun? This distance is called the *Schwarzschild radius*.